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UNITED KINGDOM

08369480001

Patents ADP number *(if you know it)*

If the applicant is a corporate body, give the country/state of its incorporation — UNITED KINGDOM

4. Title of the invention — CAMOUFLAGE COVERING

5. Name of your agent *(if you have one)*

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206680

Camouflage Covering

This invention relates to camouflage, and in particular to protecting structures from detection by more than one detection method.

It is often desirable to protect a structure such as a building or a vehicle from detection. Many means of camouflaging objects are known in the fields of surveillance and wildlife observation. These may consist of built-in protection, such as a paint covering, or removable protection, such as a camouflage net, or may be semi-permanent, such as a demountable screen for shielding a structure.

GB 565,238 describes a process and means for coating buildings and other objects for the purpose of camouflage. A paint-like coating is applied to objects which protects the objects from detection in the visible and infra-red portions of the electromagnetic spectrum.

US 5,549,938 describes a removable camouflage comprising flexible magnetic panels having camouflage patterns provided thereon. The panels are designed to magnetically attach to steel surfaces such as the panels of a vehicle. The chance of visual detection of the vehicle is thereby reduced.

US 4,560,595 discloses a sheet form camouflage material designed to have thermal emission characteristics which match closely the known thermal emission

characteristics of the natural environment in which the camouflage material is intended to be used. The sheet can protect objects against detection in the thermal infra-red wavelength ranges, and is also adapted to provide camouflage in the ultra-violet, visible and photographic infra-red wavelengths. The camouflage material may be attached to a supporting web by means of an adhesive or by mechanical means such as clamps or sewing.

Each of these camouflage systems has problems. Built-in camouflages are of limited use since they are only effective against visual detection in areas whose natural colours match closely the colour(s) of the camouflage system. For example, a temporary building, such as a flat-pack structure, painted with a sand-coloured coating would be camouflaged in desert situations, but would stand out against a jungle environment. The structure would need to be repainted if it were desired to use it in a jungle situation.

The removable camouflage panels of US 5,549,938 are also of limited use. While being convenient to apply or remove, they are only designed to protect an object against visual detection. Surveillance equipment or animals with capability to detect UV or IR emissions, for example, would easily detect the presence of an object protected by the panels.

The sheet material of US 4,560,595 cannot easily and quickly be applied to a structure. The sheet must first be attached to a supporting web, and then somehow attached to a structure to be protected. If the structure is, say, a vehicle, then the sheet must be securely attached to the vehicle to prevent it from being released when the

vehicle moves.

It is often important that a camouflage covering should be robust against severe weather and should remain in place and undamaged for extended periods of time.

A brief discussion will now be given of sensing methods available for detecting objects, and of protection means available to protect against detection.

Visible wavelengths can be used, both by land-based surveillance systems or individuals, and by satellites, to detect the presence of objects. Obviously, the position of an object in relation to its surroundings will dictate the type of camouflage cover required to protect against visual detection. The earlier examples of desert and jungle situations would require sand-coloured and patterned green coverings respectively. It is often desirable that the colour of a surface should be changed rapidly in order for a camouflage system to adapt to new surroundings.

Similarly, the surface texture of an object can lend the object to being easy or difficult to detect in visible wavelengths. Surface profiling can be used to protect objects against detection by aerial imaging. If a surface of an object is uneven then light will scatter differently from different parts of it, thus breaking up the lines of the object and rendering it difficult to detect. Shadows created by an object can also be minimised by suitable use of uneven surface profiles.

The shape of objects such as buildings is also important when protecting the objects against detection. Many vehicles and buildings are designed to have stealthy shapes

comprising multiple oriented flat panels which are not easily detected. An irregularity in the shape of a surface can render the surface susceptible to detection. For example, a bolt protruding from an otherwise smooth surface can give a strong signal on imaging equipment in certain parts of the electromagnetic spectrum.

Ultra-violet sensors can detect an object if the object transmits a UV signature substantially different from that of the object's surroundings. UV pigments can be used to give the surface of an object the correct properties such that it cannot easily be observed by UV sensors.

In an analogous manner, infra-red signatures of objects can make them easy to detect. IR pigments can be used to give an object apparently similar IR properties to the surroundings. Alternatively reflective metallic layers can be incorporated beneath an optically coloured but IR transmissive polymer film (e.g. polyethylene or polypropylene).

IR/Thermal imaging can be used to detect objects via the heat which they produce. Metallised particles or metallised fibres (scrim) incorporated into a material, or a metallised film, can be used to reflect heat produced in the object back toward the source so that the external surface of the object cannot be seen to be producing a great deal of heat. An example of a situation in which this effect might be useful is in protecting a moving vehicle from detection while the engine of the vehicle is producing a large amount of heat.

In addition, or alternatively, phase change materials can be used to absorb heat from

hot spots of objects. For instance, a phase change material which operates at a high temperature could be used to smooth out the heat signature of a boiler housing. The function of phase change materials is described in detail in our co-pending application entitled "Wall Lining".

Radar is also used in surveillance systems to detect objects. To avoid detection by this method, RADAR absorbing materials (RAMs) can be used in camouflage coverings. RAMs are discussed in US patent numbers 5,523,757 and 4,479,994.

Finally, it is often useful to absorb acoustic signals so that they cannot be detected. Materials such as high density foam, rubber and ceramics can be effective at damping acoustics.

Embodiments of the present invention can provide an improved camouflage covering which can quickly, easily and securely be applied to an object to be protected. Embodiments of the present invention can also protect an object against detection in a range of situations.

According to the present invention there is provided a covering for application on surfaces of a structure, the covering comprising at least one sheet including a plurality of components, each component being capable of protecting the structure against detection by at least one sensing method, the sheet having an adhesive exterior surface whereby it can be adhered to the structure and wherein the exterior surface opposite the adhesive surface has an uneven surface profile.

Suitably, a backing sheet could be removably attached to the adhesive surface such that the backing sheet could be removed to expose the adhesive surface. The covering could then be applied directly onto a surface of an object to be protected. Suitably, the covering could subsequently be removed from the object without damage to the object.

Suitably, the covering could comprise pigments of ultra-violet and/or infra-red. It could suitably comprise metallised scrim, and the scrim threads could be metallised with aluminium, nickel, chrome or copper.

The covering could suitably comprise one or more radio absorbing material such as carbonyl iron, Kevlar, ferrites, or carbon loaded foams. Suitable classes of RAMs include Salisbury screens, Jaumann absorbers, circuit analogue absorbers, magnetic RAM and Hybrid RAM systems.The covering could suitably comprise a flexible soft-magnetic thin film. This film would act as both RADAR absorber and Infrared reflector. Suitable examples of magnetic films include alloys of cobalt/iron/silicon/molybdenum/boron and cobalt/zirconium/niobium.One component of the covering could suitably comprise a phase change material, such as hydrated aluminium chloride, hydrated magnesium chloride, or Glauber's salt.

The covering could suitably comprise an acoustic absorber. The absorber could be of a substance such as high density foam, rubber or a ceramic system.

The sheet could preferably be flexible such that it could be rolled up for easy transportation, storage, application and manipulation.

The covering could suitably be in the form of a plurality of layers, each layer comprising one or more components which can each protect an object against detection by at least one sensing method. One of the layers could suitably be a paint layer which could either be applied directly to the object to be protected, or be applied to a surface of the covering.

Suitably, at least one of the layers of such a multi-layer covering could be removably adhered to an adjacent layer. Adhesive layers could suitably be provided between each layer of the covering. This feature of providing one or more layers which can be removed from the remaining layers could conceivably be useful in situations where it is required to alter the visual appearance of a covering while leaving the other camouflage functions of the covering unchanged. For example, a sand-coloured upper layer could be removed from a covering at a time when the covering is no longer to be used in a desert situation but is instead to be used in an area with large amounts of vegetation. It would be unnecessary to remove the entire covering, which may still be in good condition after extended use. In accordance with the present invention, the outer layer could simply be peeled off and replaced by a similar outer layer of a different pattern or colour to suit the new environment.

According to a second aspect of the present invention, there is provided a method for protecting a structure, the method comprising applying to a surface of the structure a covering having any combination of the features as set out above in relation to the first aspect of the invention.

According to a third aspect of the invention there is provided a kit comprising: a first covering according to any preceding claim; and a second covering according to any preceding claim removably adhered to the first covering.

According to a fourth aspect of the invention there is provided a kit for camouflaging surfaces comprising: a first elongate sheet patterned with two zones, the zones having different appearances, each zone extending along a relatively long dimension of the sheet, wherein one side of each zone runs continuously along a respective side of the sheet, and the other side of each zone is delimited by a boundary extending along the relatively long dimension of the sheet in a generally undulating form, such that all regions of the sheet on one side of the boundary form a zone of a first appearance and all regions of the sheet on the other side of the boundary form a zone of a second appearance; and a second elongate sheet having a continuous field of the first appearance within which are disposed isolated regions of the second appearance.

According to a fifth aspect of the invention there is provided a method for forming a covering for application on surfaces of a structure, the method comprising digitally printing the covering with a non-repeating camouflage pattern. The covering could have any other feature or combination of features as set out herein.

The invention will now be described in detail with reference to the accompanying drawings in which like reference numerals refer to like parts.

Figure 1 shows the cross section of a camouflage covering comprising several components;

Figure 2 shows a camouflage covering comprising an adhesive surface with a removable backing sheet;

Figure 3 shows an unprotected building being exposed to light;

Figure 4 shows a building protected by an embossed camouflage covering being exposed to light;

Figure 5 shows the heat signature of an unprotected boiler house;

Figure 6 shows the heat signature of a boiler house protected by a covering comprising a phase change material and metallised scrim.

Figure 1 shows a covering 1 with several components 10-15, each component having a specific purpose with regard to protecting an object from detection. Any combination of the components shown may be used in a camouflage covering, in addition to any components discussed above, and any other components having similar or different camouflage properties. The components shown in Figure 1 will now be described in turn.

Component 10 of the covering 1 is a painted or printed layer. The layer may be patterned, and is of one or more colours which provide a low contrast with the surroundings of the structure to which the covering is to be applied. The pattern of the painted or printed layer is intended to make a structure difficult to detect by, and preferably essentially invisible to, visual detection methods within a pre-decided frequency range.

Further layers of paint, or adhesive printed sheets, may be applied to the painted or printed layer 10 in order to change the colour of the covering to match different

surroundings. The printed layer 10 may be digitally printed to give a camouflage colour and pattern most suited to a specific operational environment. The colour and pattern could be generated from a set of real background images, for example by analysis of such images to establish a form of pattern that will have low contrast against the background and then forming images of that form by means of a suitable algorithm or pseudo-random procedure. Covering sheets could be individually printed for disguising specific objects against their background. Digital printing has the advantage that sheets can be printed with a non-repeating pattern. This can make the sheets less prone to detection.

Component 11 is a surface which has been embossed to give it a profiled structure. The profiled structure has a degree of surface relief and/or unevenness which acts to scatter light and other electromagnetic wavelengths from the covering in order to break up the outer surface of a structure to which the covering is to be applied. This embossed surface 11 is useful in protecting a structure against detection by aerial , IR and RADAR imaging

The dimensions of the indentations determine the frequencies of radiation against which the covering can best protect. Preferably the dimensions of the features of the surface profile – for instance the depth of grooves, the height of protrusions and/or the spacing between them – should be approximately half the wavelength of the radiation against which it is desired to protect. If, for example, it is desired to protect against infra red, then the features of the surface relief should be of the order of 0.4 to 500μm, e.g. 200μm.

Additionally, the surface profile can be used to break up the shadow of a structure. For this purpose the dimensions of the features of the surface relief should be of a scale of approximately 1 to 50cm. The relief could be provided by an array of comb-like projections from the surface of the covering.

To deflect radar, the surface indentations should preferably be regularly shaped, and around 1mm deep. Again, preferably the dimensions of the features of surface relief are approximately half the wavelength.

Component 12 contains UV and/or IR pigments. The effect of the pigments is to provide the surface of a protected structure with UV and/or IR signatures which resemble those of the surroundings. This protects the structure against detection by UV and/or IR sensors. Alternatively a metallic film positioned beneath a pigmented but IR transmissive film can be used to the same effect.

Component 13 comprises a phase change material which preferably changes phase at a certain working temperature in such a way that the phase change is endothermic on increasing temperature. In this way the phase change material acts as a thermal buffer. Preferably the working temperature of the material is around the upper or lower limit of the expected ambient temperature at the location where the covering is to be used. The layer 13 of phase change material acts to absorb heat when it reaches its phase change temperature, thus smoothing out the heat signature of structures containing heat-producing objects.

Component 14 is a metal film which assists heat dissipation. This also acts to smooth

the heat signature of the structure being protected by the covering 1, by reflecting heat towards the source and thus preventing the external surface of the structure from producing a localised heat signature.

The points 15 shown in Figure 1 represent the cross sections of metallised threads, or scrim, woven into the covering. When a covering comprising scrim is applied to every outer surface of a structure, the effect of the scrim is to produce a Faraday cage. The inside of the structure must be electrically uncharged, such that any charge placed inside the cage will be cancelled out by an equal and opposite charge spread across the exterior of the cage. A structure protected by a scrim covering is therefore difficult to detect by means of electromagnetic imaging in that it prevents transmission of EM waves in or out of the structure. In addition the scrim should protect the structure from an electromagnetic pulse. The scrim also acts to reflect heat produced within the structure.

The metallised threads 15 could be produced by electrocatalytic deposition . By this method, a thin layer of copper or aluminium could be deposited onto the surface of the fibre. As discussed above, metallised particles or a metallised film could be used in place of scrim.

An adhesive layer 16 is shown on an exterior surface of the covering 1. This allows the covering to be applied quickly and easily to a structure to be protected. The adhesive 16 could be covered by a removable backing sheet to protect the adhesive layer prior to application of the covering.

In Figure 2, the layer 17 is a backing sheet removably adhered to the covering 1 shown in Figure 1. The backing sheet 17 can be peeled off the covering in order for the covering 1 to be adhesively applied to the surface of a structure.

Figure 3 shows a building 20, such as a temporary structure erected from a flat-pack, unprotected by any camouflage covering. The building 20 is exposed to light from, say, the sun or a spotlight. It can be seen that the surface 22 of the building, i.e. the surface in the shade of the light, appears considerably darker than the surface 21 which is directly exposed to the light source. This contrast in shadow allows the structure to be detected easily by any equipment or individual scanning in the visible range of the spectrum.

In order to minimise this susceptibility, use can be made of embossed surfaces (11 in Figure 1) which act to scatter light and create shadows on surfaces of the structure to be protected. The result of this effect is shown in Figure 4 where it can be seen that surface 21 of structure 20 appears darker than in Figure 3, and surface 22 appears relatively lighter. This makes structures more difficult to detect using visible sensing methods.

Figure 5 shows a boiler house 30 without any camouflage covering. A boiler is contained within the structure and its location is shown at 31. The heat emitted by the boiler produces a heat signature as represented by contour lines 32. The source of the heat can clearly be seen, and this signature of the boiler house will be in sharp contrast to the heat signature of the natural environment in which the boiler house is situated. This will render the boiler house susceptible to detection by heat sensing surveillance

equipment.

If a covering comprising a phase change material (shown as 13 in Figure 1) is used to protect the boiler house, the heat signature of the structure will be rather different. Figure 6 shows this smoother signature. It can still be seen that there is a small heat source positioned at 31 within the boiler house 30, but the contour lines 33 have a considerably greater separation from one another than in the heat signature 32 shown in Figure 5. Since the heat signature shown by contour lines 33 is less sharp, it is more difficult to detect by IR scanning methods.

A high performance thermal insulating layer could also be included in the covering. Suitable materials for this layer would be glass fibre, microfibre or aerogels.

The inclusion in a camouflage covering of more than one of the components discussed above provides a covering which can simultaneously protect a structure from detection against multiple sensing methods. In addition, an adhesive surface allows the covering to be applied quickly and easily to a structure which needs to be protected. It may also be adapted such that, on removal of the covering, the underlying structure is undamaged and may subsequently be covered by a different covering. This feature would be useful in circumstances where structures are required to be frequently erected and dismantled.

The covering is conveniently in sheet form. The sheet may be formed of one or more sub-sheets which are laminated together to form the full covering. The sub-sheets may be bonded together either permanently or releasably by an adhesive layer carried

by one or both of the sub-sheets. In one especially preferred arrangement one of the sub-sheets includes one or more components that can inhibit detection by a sensing means such as radar or infra-red scanning, the effectiveness of which is relatively independent of the environment in which the covering may be deployed; and the other of the sub-sheets includes one or more components that can inhibit detection by a sensing means such as visible observation the effectiveness of which is relatively dependent on the environment in which the covering is to be deployed. With this system the former sub-sheet can be applied to a structure for protection in any environment. A number of variations of the latter sub-sheet can be available for use in corresponding environments: e.g. desert, temperate, jungle, snow. The latter sub-sheet is preferably deployed on the outside of the covering, further from the outer surface of the object that is to be protected, so that its surface is exposed once the sheet has been deployed. Three or more sub-sheets, each with respective protective properties could be used.

The inner sheet and the outer sheet could each be provided with an adhesive layer on one of their major surfaces. In the case of the inner sheet this can be used for attaching it to a structure that is to be protected. In the case of the outer sheet this can be used for attaching it either to such a structure or to an inner sheet that has previously been adhered to the structure. The adhesive layer of the inner sheet could be a permanent adhesive and the adhesive layer of the outer sheet could be a releasable adhesive. The adhesive layer of the inner sheet could be more adherent than the adhesive layer of the outer sheet. These configurations make it easier to apply an inner sheet to a structure, and then change its appearance to match a certain environment by removing a previously deployed outer sheet and replacing it with

another. One two or more such inner sheets could be used, one on top of another, to provide additional protection.

The or each sheet could be fitted with a removable protective sheet over its adhesive layer. The or each sheet is preferably flexible. The sheet(s) could be rolled up into a roll for distribution.

The components that help to provide protection could be formed into a sheet or layer, embedded into a sheet, and/or sandwiched between two sheets depending on the nature of the components. The or each sheet could be of a polymer material such as PVC, PVF, polypropylene, polyethylene, silicones, polysulphones or polyesters.

Figure 7 shows a pair of sheets of a covering. The sheets are relatively long in one dimension and may be rolled up for storage and easy transportation in the same way as conventional wall paper.

Each sheet 70, 75 is patterned with zones of two types. Each type of zone has a single colour or multicoloured pattern: for example the zones of the first type may be coloured green, and the zones of the second type coloured brown.

The sheet 70 is patterned such that a zone 72 of the first type extends along the longer dimension of the sheet. One side of the zone 72 runs continuously along one side of the sheet 70. The other side of the zone 72 is delimited by boundary 73. The boundary 73 extends along the longer dimension of the sheet in a generally wavy or undulating form. All regions 71 of the sheet on the other side of boundary 73 form a

zone of the second type.

The sheet 75 is patterned with zones of the same two types but in a different arrangement. This sheet has a field 76 formed by a zone of the second type on which are disposed isolated zones 78 of the first type, which are typically approximately oval

Referring now to Figure 8, if portions of the two sheets 70 and 75 are applied in a particular way to an object to be camouflaged, then a useful pattern can be obtained. Strips 80, 82 of the sheet 75 are applied along opposite sides of a surface of the object so that the zones 72 of the first type of those strips run along the edges of that surface. The region between those strips is filled with one or more strips 81 of the sheet 75. The arrangement of the portions 80, 81 and 82 is shown in Figure 8, and Figure 9 shows the overall pattern resulting from such a combination of the two sheets 70 and 75.

The effect of this is that the sides of the surface along which the zones of the first type run can be camouflaged especially effectively. For example, if the colour and/or pattern of the zones of the first type is of low contrast with the surroundings of the object then the presence of a zone of the first type continuously along two sides of the object is likely to make it more difficult to detect. In many aspects, for example woodland aspects, if the zone of the first type is dark (e.g. black) then it can visually disrupt the edges of the object by causing confusion with nearby shadows.

One especially preferably configuration is that shown in figure 9, in which the wavy

boundary 73 periodically defines wider regions of the zone of the first type, and these regions are located at the corners of the surface of the object on which the sheets are applied. This can emphasise the visual disruption at the corners of the object.

In this way, large surfaces can be covered with an effective camouflage layer without the necessity of large individual sheets. Large sheets are difficult and cumbersome to manipulate and also to store.

The sheets 70 and 75 could suitably be coated on the side opposite the patterned side with an adhesive layer, and the adhesive layer could conveniently be covered by a removable backing sheet for protecting the adhesive layer. This allows for simple and quick application of the sheets in any desired arrangement.

The applicant hereby discloses in isolation each individual feature described herein and any combination of two or more such features, to the extent that such features or combinations are capable of being carried out based on the present specification as a whole in the light of the common general knowledge of a person skilled in the art, irrespective of whether such features or combinations of features solve any problems disclosed herein, and without limitation to the scope of the claims. The applicant indicates that aspects of the present invention may consist of any such individual feature or combination of features. In view of the foregoing description it will be evident to a person skilled in the art that various modifications may be made within the scope of the invention.

CLAIMS

1. A covering for application on surfaces of a structure, the covering comprising a sheet including a plurality of components, each component being capable of protecting the structure against detection by at least one sensing method, the covering having an adhesive exterior surface whereby it can be adhered to the structure, and wherein the exterior surface opposite the adhesive surface has an uneven surface profile.

2. A covering as claimed in claim 1 further comprising a backing sheet removably adhered to the adhesive exterior surface.

3. A covering according to claim 1 or claim 2 wherein at least one of the components comprises an ultra-violet pigment.

4. A covering according to any preceding claim wherein at least one of the components comprises an infra-red pigment.

5. A covering according to any preceding claim wherein a first one of the components comprises a metallic film.

6. A covering according to claim 4 wherein a second component adjacent the

first component comprises an infra-red transparent polymer.

7. A covering according to any preceding claim wherein at least one of the components comprises metallised threads.

8. A covering according to claim 5 wherein the threads are metallised with aluminium.

9. A covering according to claim 5 wherein the threads are metallised with copper.

10. A covering according to any preceding claim wherein at least one of the components comprises a radio absorbing material.

11. A covering according to claim 10 wherein the radio absorbing material is carbonyl iron.

12. A covering according to claim 10 wherein the radio absorbing material is Kevlar.

13. A covering according to any preceding claim wherein at least one of the components comprises a phase change material.

14. A covering according to any preceding claim wherein at least one of the components comprises an acoustic absorber.

15. A covering according to claim 14 wherein the substance is rubber.

16. A covering according to claim 14 wherein the substance is a high density foam.

17. A covering according to claim 14 wherein the substance is a ceramic.

18. A covering according to any preceding claim wherein the covering is flexible.

19. A covering according to any of claims 1 to 18 wherein the covering comprises a paint.

20. A covering according to any preceding claim, wherein the covering is digitally printed with an image representing an environmental background.

21. A kit comprising:

a first covering according to any preceding claim; and

a second covering according to any preceding claim removably adhered to the first covering.

22. A method for protecting a structure, the method comprising applying to a surface of the structure a covering or kit according to any preceding claim.

23. A method according to claim 22 wherein the covering is of a colour that has

low contrast with the surroundings of the structure.

24. A kit for camouflaging surfaces comprising:

a first elongate sheet patterned with two zones, the zones having different appearances, each zone extending along a relatively long dimension of the sheet, wherein one side of each zone runs continuously along a respective side of the sheet, and the other side of each zone is delimited by a boundary extending along the relatively long dimension of the sheet in a generally undulating form, such that all regions of the sheet on one side of the boundary form a zone of a first appearance and all regions of the sheet on the other side of the boundary form a zone of a second appearance; and

a second elongate sheet having a continuous field of the first appearance within which are disposed isolated regions of the second appearance.

25. A kit according to claim 24 wherein the widths of the two sheets are substantially the same.

26. A kit according to claim 24 or 25, wherein the sheets have an adhesive layer on the sides opposite the patterned sides.

27. A kit according to claim 26 wherein the adhesive layer is covered by a removable backing sheet.

28. A kit according to any of claims 24-27 wherein the sheets are flexible

29. A method for forming a covering for application on surfaces of a structure, the method comprising digitally printing the covering with a non-repeating camouflage pattern.

ABSTRACT

Camouflage Covering

A covering for application on surfaces of a structure, the covering comprising at least one sheet including a plurality of components, each component being capable of protecting the structure against detection by at least one sensing method, the sheet having an adhesive exterior surface whereby it can be adhered to the structure and wherein the exterior surface opposite the adhesive surface has an uneven surface profile.

Figure 1

Fig. 1

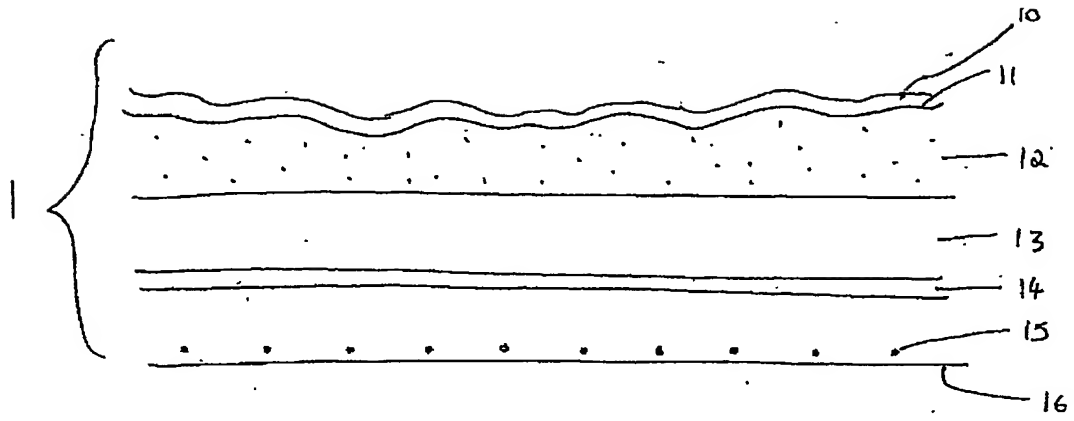


Fig. 2

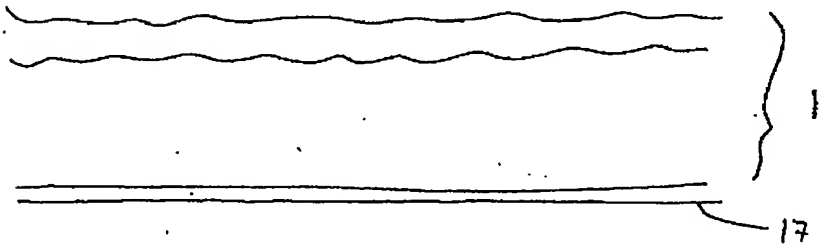
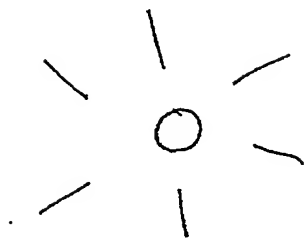


Fig. 3



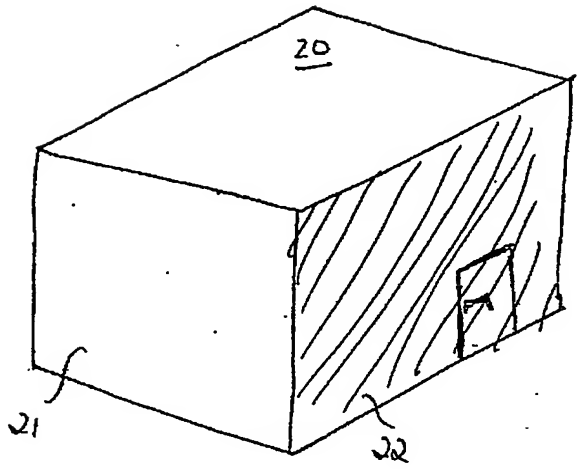
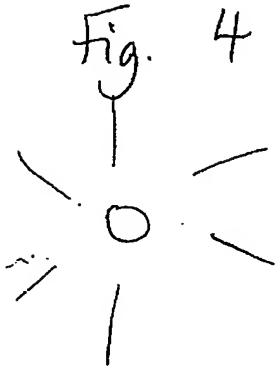


Fig. 4



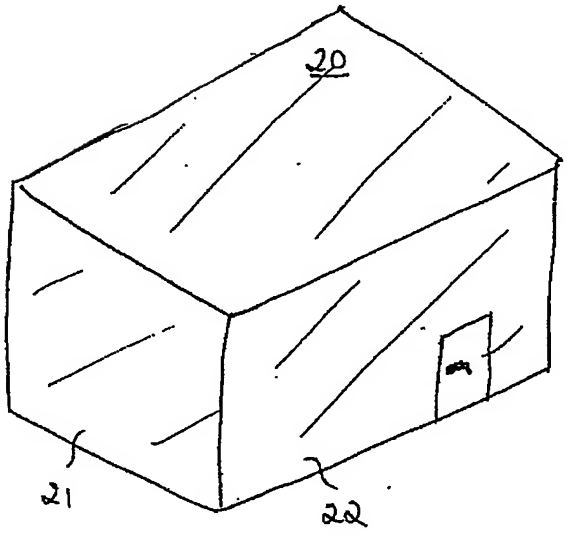


Fig. 5

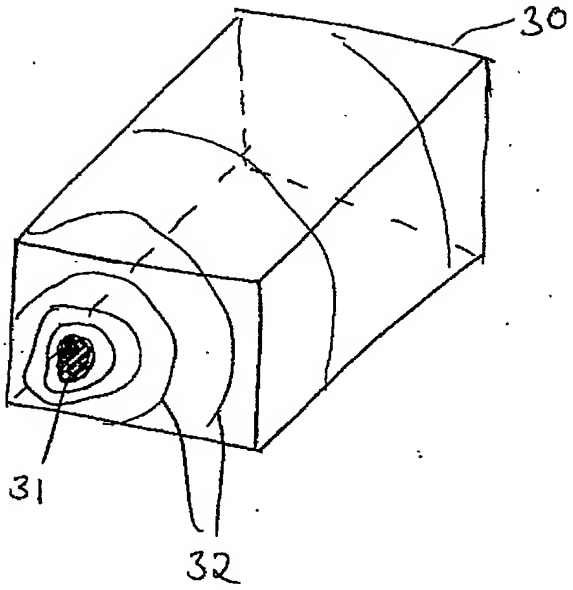
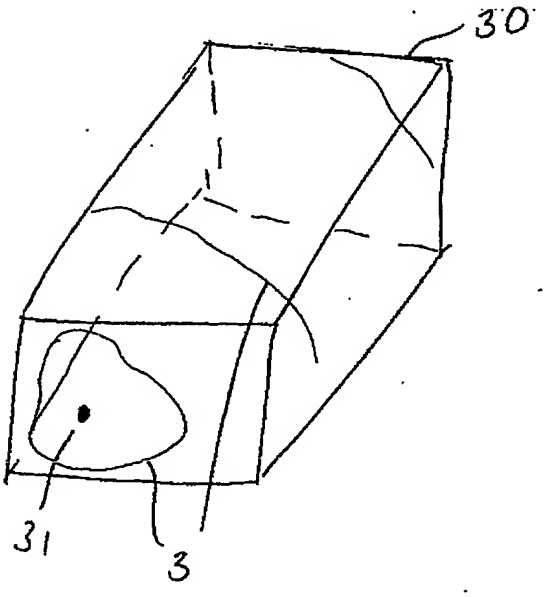


Fig. 6



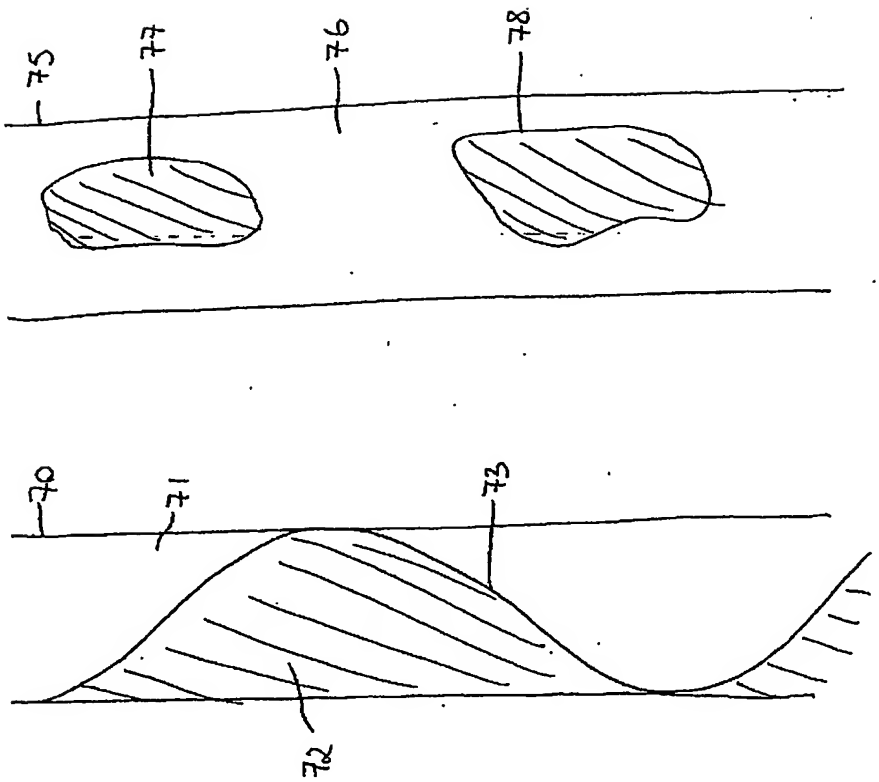


Fig. 7

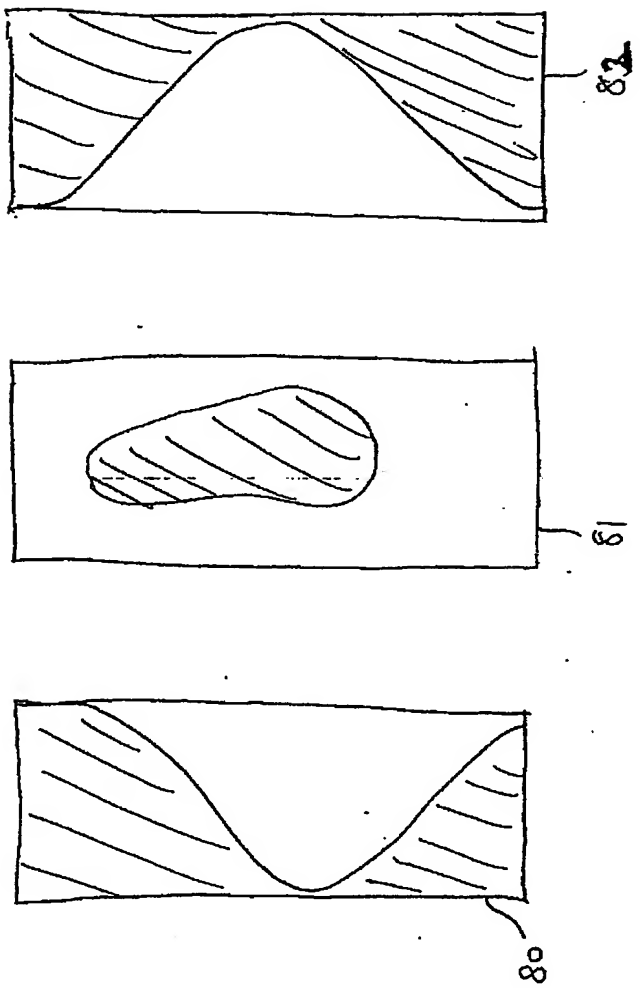


Fig. 8

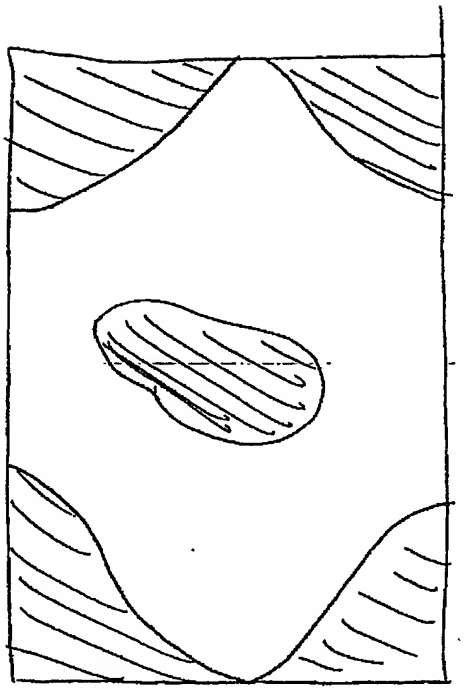


Fig. 6